29th International Cosmic Ray Conference Pune (2005) **1**, 221-224

The Ground Level Enhancements of 20 January 2005 and 28 October 2003

H. Moraal[a*], K.G. McCracken[b], C.C. Schoeman[a] and P.H. Stoker[a]
(a) Unit for Space Physics, North-West University, Private Bag X6001, Potchefstroom 2520, South Africa.
(b) Institute for Physical Science and Technology, University of Maryland, College Park, Md. 27402, U.S.A.
Presenter: H. Moraal (fskhm@puk.ac.za), saf-moraal-H-abs3-sh15-poster

The Ground Level Enhancement of 20 January 2005 was one of the largest on record. The SANAE neutron monitor saw an unusual triple-peak increase during this event. It appears that this intensity profile can be understood in terms of a simple pitch angle distribution nominally along the heliospheric magnetic field line. The event of 28 October 2003 was accompanied by the emission of solar neutrons seen on the Tsumeb neutron monitor as was reported previously. It is shown that these neutrons were also observed by the Hermanus neutron monitor.

1. Introduction

The Ground Level Enhancement (GLE) of 20 January 2005 was one of the largest on record. The largest and earliest increases in this event were seen by the South Pole and McMurdo neutron monitors that recorded increases of 5400% and 2900% at 06:54, respectively. (The increase at South Pole corrected to sea level was ≈ 1800%). The SANAE neutron monitor recorded three peaks during this event, and it seems to be the only neutron monitor that did so. In the final version of this paper we will attempt to explain this time-intensity profile in terms of a simple pitch angle distribution along the nominal heliospheric magnetic field line.

2. Observations

The upper left hand panel of Figure 1 shows the intensity of the six-counter SANAE NM64 neutron monitor, as well as that of the four-counter neutron moderated detector (NMD) from 06:30 to 08:00 on 20 January 2005. The observed GLE was associated with a solar flare that erupted at 14^o N, 67^o W on the sun. Soft X-ray emission from the X7.9 flare was first seen at 06:21, it peaked at 06:50, and ended at 07:27. A coronal mass ejection (CME) was observed to lift off from the corona at 06:36. From ≈ 06:00 to 07:30 the HMF was basically directed from South to North, with a magnitude of 5 nT. The solar wind speed was ≈ 800 km/s, and both the field and solar wind speed were quiet, supported by a low level of geomagnetic activity. The intensity increases of several other high latitude neutron monitors were investigated, especially those of Spaceship Earth (Bieber et al., 2002). None of these monitors saw the clear 3-peak structure seen at SANAE.

3. Preliminary Interpretation

The other three panels of Figure 1 plot the increases of 13 neutron monitors as function of their asymptotic direction of viewing for the times that the SANAE neutron monitor saw the three peaks. The magnitude of the increase for each neutron monitor is shown, and the size of the symbol is proportional to this increase. This plot suggests that the first peak at 06:54 was highly anisotropic, with a beam of particles arriving from ~ 40^o S, 40^o W. This direction was not more than 60^o from the HMF direction. The anisotropy was such that the intensity falls off by a factor of 10 for pitch angles from 0 to 80^o. By the time of the second maximum at 07:12 the anisotropy had decreased considerably and the maximum had shifted equatorward. The third increase at 07:24 was even more isotropic.

The asymptotic direction of viewing of the SANAE neutron monitor on Figure 1 is for 1.5 GV particles, while it spreads out considerably eastward for lower rigidities. In the final version of the paper these observations will be interpreted in terms of the asymptotic directions of viewing of SANAE as function of rigidity.

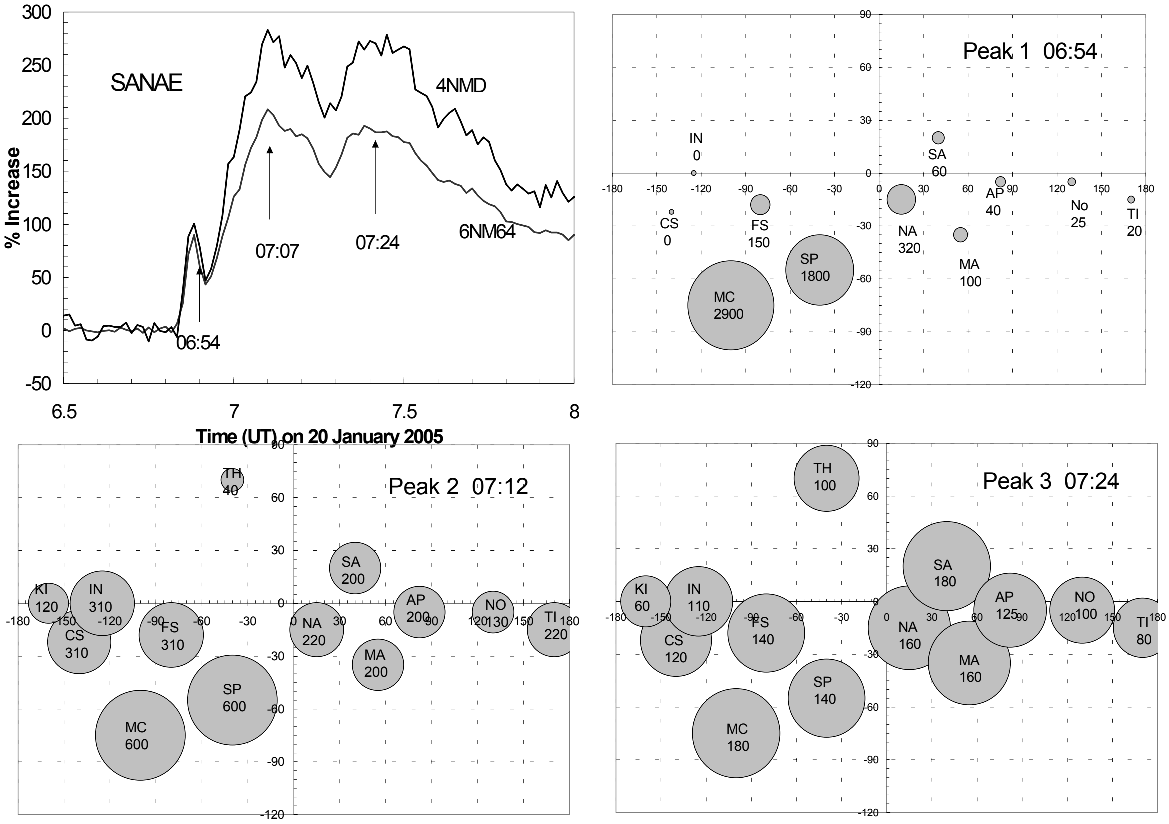

Figure 1. Top left: The three peaks seen by the SANAE neutron monitor during the GLE of 20 January 2005. The other three diagrams show the percentage intensity increase for 13 neutron monitors in their asymptotic directions of viewing during the three peaks. The size of the circles is proportional to the increase. AP = Apatity, CS = Cape Schmidt, FS = Fort Smith, IN = Inuvik, KI = Kingston, MA = Mawson, MC = McMurdo, NA = Nain, NO = Norilsk, SA = Sanae, SP = South Pole, TH = Thule, TI = Tixie Bay.

4. Solar neutrons observed during the 28 October 2003 GLE

The 28 October 2003 GLE was studied by Bieber *et al*. (2005), Miroshnichenko *et al*. (2005) and Plainaki *et al*. (2005). In these papers it was found that this event, of which the first relativistic protons were seen at 11:13 UT, was also accompanied by solar neutrons seen at the Tsumeb neutron monitor, at cutoff rigidity 9.1 GV. These solar neutrons were observed between ~ 11:06 and 11:15. From the atmospheric depth of Tsumeb and the angle of viewing relative to the sub-solar point, Miroshnichenko *et al.* estimated that these neutrons had a minimum energy of 200 MeV. Here we report that the Hermanus neutron monitor also saw these neutrons.

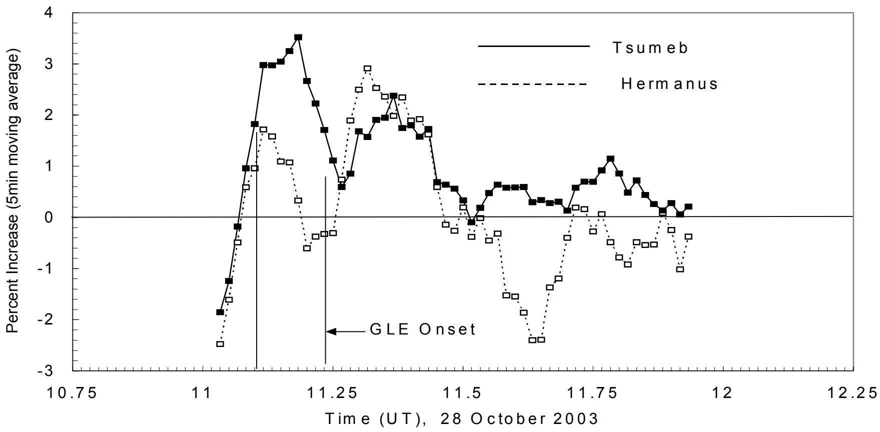

Figure 2. Five minute running averages of the Tsumeb and Hermanus increases during the GLE of 28 October 2003.

Figure 2 plots the counting rate of the Tsumeb neutron monitor during this event, together with that of Hermanus, with a cutoff rigidity of 4.9 GV. The neutron event identified by the authors mentioned above is clearly visible between the two vertical lines at 11:06 and 11:14. This figure also shows that there is a similar increase on the Hermanus neutron monitor, also starting at 11:06. The net increase is smaller than at Tsumeb, but during the rise of the event Hermanus tracks Tsumeb almost perfectly. The zenith angles to the sun at 11:10 UT were 14.6o at Tsumeb and 29.7o at Hermanus. Taking into account the altitude difference (1240 m for Tsumeb and 43 m for Hermanus), the atmospheric thickness in the direction of the sun was 926 g cm-2 for Tsumeb and 1187 g cm-2 for Hermanus. Since there is a factor of ~2 difference in the peak intensity, this difference gives an extinction rate of ~7x10-5 per gcm-2, which is in general agreement with the result of Chupp et al. (1987), establishing that the Hermanus increase is likely due to neutrons. More detailed calculations will be given in the final version of the paper.

The Potchefstroom neutron monitor is even nearer aligned with the Tsumeb monitor than Hermanus is, but its counting rate was too low to resolve this event.

Figure 2 also indicates that Tsumeb detected an excess of ~ 2% after the onset of the GLE at 11:14, which has implications for the hardness of the spectrum.

5. Acknowledgements

This work was funded by the South African National Antarctic Programme We thank scientists of Izmiran and Polar Geophysical Institutes of the Russian Academy of Sciences, the Australian Antarctic Division, and the Bartol Research Institute for the use of their data. Neutron monitors of the Bartol Research Institute are supported by NSF grant ATM-0000315.

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